Wanyu Rengie Chan, Ph.D

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EDUCATION

Ph.D. **University of California, Berkeley**
Environmental Engineering Program, Civil & Environmental Engineering, 2006

M.S. **University of California, Berkeley**
Civil & Environmental Engineering, 2002

B.S. **Carnegie Mellon University, Pittsburgh PA**
Chemical Engineering, 2001

RESEARCH INTERESTS

- Indoor air quality
- Building ventilation and energy efficiency
- Indoor airflow and pollutant transport
- Air pollutant exposure assessment and mitigation
- Wildfire smoke

RESEARCH / PROFESSIONAL EXPERIENCE

Research Scientist, Lawrence Berkeley National Laboratory 2010–Current
Deputy Group Leader (2016–Current), Indoor Environment Group

Indoor Air Quality, Health & Productivity

Principal Investigator:

Indoor Air Quality Scientific Findings Resource Bank, Indoor Environments Division, U.S. Environmental Protection Agency 2019–Current

Commercial Bldg Indoor Air Quality, Ventilation & Energy Efficiency

Co-Principal Investigator:

Measurement and Control of Ventilation Rates in California Commercial Buildings (VentCon), Contract # PIR-14-003, California Energy Commission 2014–2018

Healthy Zero Energy Buildings Project (HZEB), Contract # 500-09-049, California Energy Commission 2011–2015

Technical Lead:

Ventilation Solutions for Energy Efficient California Schools – Improving Indoor Air Quality through Advanced, High Performance HVAC, Contract # EPC-15-033, California Energy Commission 2016–2019

Contributor:

Small and Medium Building Efficiency Toolkit and Community Demonstration Program (SMB Toolkit), Contract # PIR-12-031, California Energy Commission 2015–2017

Residential Bldg Indoor Air Quality, Ventilation & Energy Efficiency

Co-Principal Investigator:

Effective Kitchen Ventilation for Healthy ZNE Homes with Natural Gas, Contract # PIR-16-012, California Energy Commission — 2016–2019

Technical Lead:

New Home Indoor Air Quality Field Study, Building America Program, U.S. Department of Energy — 2018–Current

Healthy Efficient New Gas Homes (HENGE), Contract # PIR-14-007, California Energy Commission — 2014–2018

Contributor:

Deep Energy Retrofits Cost Stack, Building America Program, U.S. Department of Energy — 2019–Current

Natural Gas Leakage from Residential Buildings in California, Contract # 500-13-008, California Energy Commission — 2016–2018

Residential Energy Savings from Air-Tightness and Ventilation Excellence (RESAVE), Contract # 500-08-061, California Energy Commission — 2010–2013

Indoor Exposure During Emergency Response

Principal Investigator:

Modeling Support for Material Threat Assessment 2.0, subcontractor to Lawrence Livermore National Laboratory — 2014–2015

Senior Scientist, Environmental & Earth Sciences, Exponent, Inc. — 2007–2010

- Performed air dispersion modeling and indoor air quality assessment
- Conducted ambient air sampling and field testing

Graduate Student Research Assistant, Lawrence Berkeley National Lab. — 2002–2006

- Developed model to predict the effectiveness of shelter-in-place
- Transferred model code in collaboration with National Atmospheric Release Advisory Center, Lawrence Livermore National Lab.

Research Assistant, Carnegie Mellon University — 2000–2001

- Conducted ambient monitoring for the Pittsburgh Atmospheric Particulate Matter Supersite Program
- Assisted in the development and testing of a method for in-situ measurement of ambient fine aerosol water content

MENTORING EXPERIENCE

Mentor several postdocs, graduate and undergraduate students each year — 2010–Current

TEACHING EXPERIENCE

Teaching Assistant, Civil & Environmental Engineering, UC Berkeley

Air Quality Engineering (Graduate Division) — Fall 2004
Atmospheric physics & chemistry; characterization & control of air pollution

Climate Change Mitigation (Upper Division) — Spring 2004
Assessment of technological options in response to climate change

AWARDS

SPOT Recognition Award, Lawrence Berkeley National Laboratory 2011
Recognized for contribution to the Healthy Zero Energy Building Program as the co-Principal Investigator.

Outstanding Performance Award, Lawrence Berkeley National Laboratory 2005
Recognized for exceptional progress and advancements in modeling health consequences and response strategies in an outdoor release.

Outstanding Graduate Student Instructor Award, UC Berkeley 2005
Nominated by faculty and outstanding teaching performance evaluation from students.

Federal Laboratory Consortium Award for Excellence in Technology Transfer (Team Award), Department of Energy 2004
Recognized for advices and technical work towards improving the security of buildings and inhabitants, and the effectiveness of local emergency response.

PROFESSIONAL ORGANIZATIONS

- Member of International Society of Indoor Air Quality and Climate (ISIAQ)
- Member of ASHRAE, currently serving on 62.2/90.2 Working Group on Advanced Ventilation

INVITED TALKS

- Meta-analysis on dampness and mold in schools and health. 2020. Presented at U.S. Environmental Protection Agency Federal Interagency Committee Meeting on Indoor Air Quality. March 11.
- Health benefits and costs of filtration. 2019. Presented at U.S. Environmental Protection Agency web summit titled "Indoor Air Filtration to Protect Public Health during Wildland Fire Smoke Episodes – What are the Knowns and Unknowns?" June 12–13.
- Air cleaners and ventilation as indoor environmental interventions – Potential risks and mitigations. 2018. Presented at American Thoracic Society workshop titled "Personal Interventions to Reduce Exposure Levels and Health Risks from Outdoor Air Pollution." May 19.

PUBLICATIONS

Refereed Journals

1. Chan W.R., X. Li, B.C. Singer, T. Pistochini, D. Vernon, S. Outcault, A. Sanguinetti, and M. Modera. 2020. Ventilation rates in California classrooms: Why many recent HVAC retrofits are not delivering sufficient ventilation. *Building and Environment* 167. DOI: 10.1016/j.buildenv.2019.106426

2. Fisk W.J., B.C. Singer, and W.R. Chan. 2020. Association of residential energy efficiency retrofits with indoor environmental quality, comfort, and health: A review of empirical data. *Building and Environment* 180. DOI: 10.1016/j.buildenv.2020.107067

3. Singer B.C., W.R. Chan, Y.S. Kim, F.J. Offermann, and I.S. Walker. 2020. Indoor air quality in California homes with code-required mechanical ventilation. *Indoor Air* 30, 885–899. DOI: 10.1111/ina.12676

4. Sohn M.D., X. Li, and W.R. Chan. 2020. Estimates of pollutant temporal and spatial variability in commercial buildings form the Joint Urban 2023 field experiments. *Indoor Air* 30, 335–345. DOI: 10.1111/ina.12626

5. Zhao H., W.R. Chan, S. Cohn, W.W. Delp, I.S. Walker, and B.C. Singer. 2020. Indoor air quality in new and renovated low-income apartments with mechanical ventilation and natural gas cooking in California. *Indoor Air*. DOI: 10.1111/ina.12764
6. Fisk W.J., W.R. Chan, and A.L. Johnson. 2019. Does dampness and mold in schools affect health? Results of a meta-analysis. *Indoor Air* 29(6), 895–902. DOI: 10.1111/ina.12588
7. Fischer M.L., W.R. Chan, W. Delp, S. Jeong, V. Rapp, and Z. Zhu. 2018. An estimate of natural gas methane emissions from California homes. *Environmental Science & Technology* 52, 10205–10213. DOI: 10.1021/acs.est.8b03217
8. Chan W.R., J.M. Logue, X. Wu, N.E. Klepeis, W.J. Fisk, F. Noris, and B.C. Singer. 2017. Quantifying fine particle emission events from time-resolved measurements: Method description and application to 18 California low-income apartments. *Indoor Air* 28, 89–101. DOI: 10.1111/ina.12425
9. Fisk W.J. and W.R. Chan. 2017. Effectiveness and costs of reducing particle-related mortality with particle filtration. *Indoor Air* 27(5), 909–920. DOI: 10.1111/ina.12371
10. Fisk W.J. and W.R. Chan. 2016. Health benefits and costs of filtration interventions that reduce indoor exposure to PM2.5 during wildfires. *Indoor Air* 27(1), 191–204. DOI: 10.1111/ina.12285
11. Chan W.R., S. Parthasarathy, W.J. Fisk, and T.E. McKone. 2016. Estimated effect of ventilation and filtration on chronic health risks in U.S. offices, schools, and retail stores. *Indoor Air* 26(2), 331–343. DOI: 10.1111/ina.12189
12. Chan W.R., M. Sidheswaran, and W.J. Fisk. 2016. Cooking-related PM2.5 and acrolein measured in grocery stores. *Indoor Air* 26(3), 489–500. DOI: 10.1111/ina.12218
13. Chan W.R., S. Cohn, M. Sidheswaran, D.P. Sullivan, and W.J. Fisk. 2015. Contaminant levels, source strengths, and ventilation rates in California retail stores. *Indoor Air* 25(4), 381–392. DOI: 10.1111/ina.12152
14. Chan W.R., I.S. Walker, and M.H. Sherman. 2015. Durable airtightness in single-family dwellings: field measurements and analysis. *International Journal of Ventilation* 14(1), 27–38. DOI: 10.1080/14733315.2015.11684067
15. Dutton S.M., M.J. Mendell, W.R. Chan, M. Barrios, M.A. Sidheswaran, D.P. Sullivan, E.A. Eliseeva, and W.J. Fisk. 2015. Evaluation of the indoor air quality minimum ventilation rate procedure for use in California retail buildings. *Indoor Air* 25(1), 93–104. DOI: 10.1111/ina.12125
16. Maddalena R., M.J. Mendell, E. Eliseeva, W.R. Chan, D. Sullivan, M. Russell, U. Satish, and W.J. Fisk. 2015. Effects of ventilation rate per person and per floor area on perceived air quality, sick building symptoms and decision making. *Indoor Air* 25(4), 362–370. DOI: 10.1111/ina.12149
17. Mendell M.J., E.A. Eliseeva, M. Spears, W.R. Chan, S. Cohn, D.P. Sullivan, and W.J. Fisk. 2015. A longitudinal study of ventilation rates in California office buildings and self-reported occupant outcomes including respiratory illness absence. *Building and Environment* 92, 292–304. DOI: 10.1016.j.buildenv.2015.05.002
18. Dutton S.M., M.J. Mendell, W.R. Chan, M. Barrios, M. Sidheswaran, D.P. Sullivan, E.A. Eliseeva, and W.J. Fisk. 2014. Evaluation of the indoor air quality minimum ventilation rate procedure for use in California retail buildings. *Indoor Air* 25(1), 93–104. DOI: 10.1111/ina.12125

19. Chan W.R., J. Joh, and M.H. Sherman. 2013. Analysis of air leakage measurements of US houses. *Energy and Buildings* 66, 616–625. DOI: 10.1016/j.enbuild.2013.07.047
20. Walker I.S., M.H. Sherman, J. Joh, and W.R. Chan. 2013. Apply large datasets to developing a better understanding of air leakage measurement in homes. *International Journal of Ventilation* 11(4), 323–338. DOI: 10.1080/14733315.2013.11683991
21. Murphy B.L., and W.R. Chan. 2011. A multi-compartment mass transfer model applied to building vapor intrusion. *Atmospheric Environment* 45(37), 6650–6657. DOI: 10.1016/j.atmosenv.2011.09.009
22. Bigham G., W.R. Chan, M. Dekermenjian, and A. Reza. 2008. Indoor concentrations of mercury vapor following various spill scenarios. *Environmental Forensics* 9(2), 187–196. DOI: 10.1080/15275920802121975
23. Chan W.R., W.W. Nazaroff, P.N. Price, and A.J. Gadgil. 2008. Effectiveness of urban shelter-in-place. III: Commercial districts. *Building Simulation* 1, 144–157. DOI: 10.1007/s12273-008-8312-8
24. Chan W.R., W.W. Nazaroff, P.N. Price, and A.J. Gadgil. 2007. Effectiveness of urban shelter-in-place–II: Residential districts. *Atmospheric Environment* 41, 7082–7095. DOI: 10.1016/j.atmosenv.2007.04.059
25. Chan W.R., W.W. Nazaroff, P.N. Price, and A.J. Gadgil. 2007. Effectiveness of urban shelter-in-place–I: Idealized conditions. *Atmospheric Environment* 41, 4962–4876. DOI: 10.1016/j.atmosenv.2007.01.041
26. Chan W.R., W.W. Nazaroff, P.N. Price, M.D. Sohn, and A.J. Gadgil. 2005. Analyzing a database of residential air leakage in the United States. *Atmospheric Environment* 39, 3445–3455. DOI: 10.1016/j.atmosenv.2005.01.062
27. Stanier C., A. Khlystov, W.R. Chan, M. Mandiro, and S. Pandis. 2004. A method for the in-situ measurement of fine aerosol water content of ambient aerosol: the dry-ambient aerosol size spectrometer (DAASS). *Aerosol Science and Technology* 38(S1), 215–228. DOI: 10.1080/02786820390229525

Article in Book

1. Sherman M.H., and W.R. Chan. 2006. Building airtightness: research and practice. In *Building Ventilation–The State of the Art*. M. Santamouris, P. Wouters (Eds), Earthscan, London, 137–162.

Conference Presentations

1. Martin E., T. Khan, D. Chasar, J. Sonne, S. Rosenberg, C. Antonopoulos, C. Metzger, W.R. Chan, B.C. Singer, and M. Lubliner. 2020. Characterization of mechanical ventilation systems in new U.S. homes: What types of systems are out there and are they functioning as intended? ACEEE Summer Study, August 17–21.
2. Chan W.R., C. Antonopoulos, and D. Chasar. 2020. Mechanical ventilation and IAQ in new homes. RESENT Conference, Scottsdale, Arizona, February 24–26.
3. Chan W.R. Indoor environmental quality, building health, and comfort. 2019. Energy Exchange Conference, Denver, Colorado, August 20–22.
4. Kim Y.S., B.C. Singer, W.R. Chan, and I.S. Walker. 2019. Investigation of quantitative relationships between occupant satisfaction and household IAQ-related characteristics in California homes. ASHRAE Winter Meeting Conference. Atlanta, Georgia, January 12–16.
5. Chan W.R. 2018. Challenges to provide adequate ventilation in buildings. ACEEE Conference on Health, Environment, and Energy, New Orleans, Louisiana, December 3–5.

6. T. Pistochini and W.R. Chan. 2018. Ensuring proper installation and commissioning of HVAC systems for energy efficiency and indoor air quality. Green California Summit, Sacramento, California, April 10.
7. Walker I.S., Y.S. Kim, B.C. Singer, and W.R. Chan. 2017. Assessing occupant and outdoor air impacts on indoor air quality in new California homes. 38th AVIC Conference, Nottingham, United Kingdom, September 13–14.
8. Chan W.R., M. Spears, R. Maddalena, C. Stratton, B. Singer, I. Walker, M. Sherman, and Y.S. Kim. 2016. Healthy Efficient New Gas Home (HENGH) – Survey and field test preliminary results. ASHRAE/AIVC IAQ 2016: Defining Indoor Air Quality: Policy, Standards and Best Practices, Alexandria, Virginia, September 12–14.
9. Singer B.C., J. Logue, W.R. Chan, and N. Klepeis. 2016. Population Impact Assessment Model (PIAMF): A tool to investigate effects of infiltration and indoor emissions on PM2.5 exposures in U.S. homes. ASHRAE/AIVC IAQ 2016: Defining Indoor Air Quality: Policy, Standards and Best Practices, Alexandria, Virginia, September 12–14.
10. Chan W.R. and M.H. Sherman. 2014. Durable airtightness in single-family dwellings: field measurements and analysis. 35th AIVC/4th TightVent/2nd VentCool Conference, Poznan, Poland, September 24–25.
11. Chan W.R., T. Hotchi, and W. Fisk. 2014. Automated control of ventilation and filtration to improve indoor air quality in residences. Indoor Air Conference, Hong Kong, July 7–12.
12. Chan W.R., M. Sidheswaran, S. Cohn, D. Sullivan, and W. Fisk. 2014. Contaminant source strength and ventilation rates in retail stores–implications to California's building energy efficiency standards. Indoor Air Conference, Hong Kong, July 7–12.
13. Chan W.R. 2014. Contaminant levels and source strengths in California retail stores. ASHARE Annual Conference, Seattle, Washington, June 29–July 2.
14. Chan W.R. and M.H. Sherman. 2013. Building envelope and duct airtightness of new US dwellings. Thermal performance of the exterior envelopes of whole buildings XII, Clearwater Beach, Florida, December 1–5.
15. Chan W.R. and M.H. Sherman. 2013. Improving building envelope and duct airtightness of US dwellings – The current state of energy retrofits. 2013. AIVC Airtightness Workshop, 3rd TightVent Workshop on Building and Ductwork Airtightness, Washington DC, April 18–19.
16. Logue J.M., M.H. Sherman, I.S. Walker, W.R. Chan, and B.C. Singer. 2013. Energy impacts of envelope tightening and mechanical ventilation for the U.S. residential sector. AIVC Airtightness Workshop, 3rd TightVent Workshop on Building and Ductwork Airtightness, Washington DC, April 18–19.
17. Logue J.M., W.R. Chan., and B.C. Singer. 2012. Acrolein exposure in selected microenvironments–concentrations and health risk. 22nd Annual Meeting of International Society of Exposure Science, Seattle, Washington, October 28–November 1.
18. Sidheswaran M., W.R. Chan, and R.L. Maddalena. 2012. Comprehensive VOC profiles in retail stores. 22nd Annual Meeting of International Society of Exposure Science, Seattle, Washington, October 28–November 1.
19. Chan W.R., J. Joh, and M.H. Sherman. 2012. Air leakage of US homes: regression analysis and improvements from retrofit. 33rd Air Infiltration and Ventilation Centre and 2nd TightVent Conference. Copenhagen, Denmark, October 11–12.

20. Chan W.R., and M.D. Sohn. 2012. Outdoor-to-indoor modeling using HPAC-CONTAM. 16th Annual George Mason University Conference on Atmospheric Transport and Dispersion Modeling, Fairfax, Virginia, July 17–18.
21. Chan W.R., and M.D. Sohn. 2012. Comparison of toxic load consequence assessments based on HPAC and VTHREAT prediction. 16th Annual George Mason University Conference on Atmospheric Transport and Dispersion Modeling, Fairfax, Virginia, July 17–18.
22. Chan W.R., M. Sidheswaran, D. Sullivan, S. Cohn, and W. Fisk. 2012. Contaminant levels and source strengths in U.S. retail stores – a pilot study. 10th International Conference on Healthy Buildings, Brisbane, Queensland, July 8–12.
23. Srinandini P., W.R. Chan, W. Fisk, and T. McKone. 2012. Modeling indoor exposures to VOCs and SVOCs as ventilation rates vary. 10th International Conference on Healthy Buildings, Brisbane, Queensland, July 8–12.
24. Chan W.R., Sherman M.H. 2011. Preliminary analysis of U.S. residential air leakage database v.2011. 32nd Air Infiltration and Ventilation Centre and 1st TightVent Conference, Brussels, Belgium, October 12–13.
25. Apte M., W.R. Chan, S. Dutton, M. Mendell, and H. Willem. 2011. Study design of the Healthy Zero Energy Building (HZEB) research program in California. 12th International Conference on Indoor Air Quality and Climate, Austin, Texas, June 5–10.
26. Chan W.R., and M.D. Sohn. 2011. Estimates of shelter-in-place effectiveness: how important is outdoor concentration fluctuation? 12th International Conference on Indoor Air Quality and Climate, Austin, Texas, June 5–10.
27. Gunaseelan P., C. Buehlur, and W.R. Chan. 2009. In profile: carbon dioxin emissions from U.S. petroleum refining. 102nd Air and Waste Management Association Annual Conference and Exhibition, Detroit, Michigan, June 16–19.
28. Chan W.R., G. Bigham, and M. Dekermenjian. 2008. Exposure to elemental mercury from a spill. 11th International Conference on Indoor Air Quality and Climate, Copenhagen, Denmark, August 17–22.
29. Chan W.R., J. Levy, B. Murphy, and J. Lingle. 2008. Air emissions and exposure from remediation of former manufactured gas plant sites. 101st Air and Waste Management Association Annual Conference and Exhibition, Portland, Oregon, June 24–26.
30. Chan W.R., and W. Shields. 2007. Deposition of dioxin in attics from backyard burning. 27th International Symposium on Halogenated Persistent Organic Pollutants, Tokyo, Japan, September 2–7.
31. Chan W.R., W.W. Nazaroff, P.N. Price, and A.J. Gadgil. 2005. Factors affecting indoor health effects owning to an outdoor toxic release. 15th Annual International Society of Exposure Assessment Conference, Tucson, Arizona, October 30–November 3.
32. Chan W.R., P.N. Price, A.J. Gadgil, and W.W. Nazaroff. 2005. Distribution of residential air leakage: implications for health consequences for an outdoor toxic release. 10th International Conference on Indoor Air Quality and Climate, Beijing, China, September 4–9.
33. Chan W.R., P.N. Price, A.J. Gadgil, W.W Nazaroff, G. Loosmore, and G. Sugiyama. 2004. Modeling shelter-in-place including sorption on indoor surfaces. 84th Annual Meeting of the American Meteorological Society, Seattle, Washington, January 11–15.

Other Publications

1. Chan W.R., S. Kumar, A.L. Johnson, and B.C. Singer. 2002. Simulation of short-term exposure to NO2 and PM2.5 to inform capture efficiency standards. LBNL-2001332. Lawrence Berkeley National Laboratory, Berkeley, California.
2. Pistochini T., C. Mande, M. Modera, S. Outcault, A. Sanguinetti, W.R. Chan, S. Dutton, B. Singer, and X. Li. 2020. Improving ventilation and indoor environmental quality in California K-12 schools. CEC-500-2020-049. California Energy Commission, Sacramento, California.
3. Chan W.R., Y.S. Kim, B. Less, B.C. Singer, and I.S. Walker. 2019. Ventilation and indoor air quality in new California homes with gas appliances and mechanical ventilation. LBNL-2001200R1. Lawrence Berkeley National Laboratory, Berkeley, California.
4. Walker I.S., W.R. Chan, and B.C. Singer. 2019. Ventilation and IAQ in new California homes. Home Energy Magazine, Spring 2019.
5. Chan W.R., S.M. Dutton, and W.J. Fisk. 2019. Measurement and Control of Ventilation Rates in California Commercial Buildings. CEC-500-2019-056. California Energy Commission, Sacramento, California.
6. Piette M.A., T. Hong, W.J. Fisk, N. Bourassa, W.R. Chan, Y. Chen, I.H.Y. Cheung, T. Hotchi, M. Kloss, S.H. Lee, P.N Price, O. Schetrit, K. Sun, S. Taylor-Lange, and R. Zhang. 2017. Small and Medium Building Efficiency Toolkit and Community Demonstration Program. LBNL-2001054. Lawrence Berkeley National Laboratory, Berkeley, California.
7. Chan W.R., Y.S. Kim, B.C. Singer, I.S. Walker, and M.H. Sherman. 2016. Healthy Efficient New Gas Home (HENGH) field study protocol. LBNL-1005819. Lawrence Berkeley National Laboratory, Berkeley, California.
8. Chan W.R., R.L. Maddalena, J.C. Stratton, T. Hotchi, B.C. Singer, I.S. Walker, and M.H. Sherman. 2016. Healthy Efficient New Gas Home (HENGH) pilot test results. 2016. LBNL-1005818. Lawrence Berkeley National Laboratory, Berkeley, California.
9. Fisk W.J., W.R. Chan, S. Cohn, H. Destaillats, S.M. Dutton, E.A. Eliseeva, R.L. Maddalena, T.E. McKone, M.J. Mendell, S. Parthasarathy, M.L. Russell, U. Satish, M. Sidheswaran, M. Spears, D.P. Sullivan, and H. Willem. 2015. Commercial Building Ventilation Effects on Indoor Air Quality, Human Health and Performance, and Building Energy Use and Implications for Future Ventilation Standards. CEC-500-2016-048. California Energy Commission, Sacramento, California.
10. Mills E., J. Granderson, W.R. Chan, D. Diamond, P. Haves, B. Nordman, P. Matthew, M.A. Piette, G. Robinson, and S. Selkowitz. 2015. Green, clean, & mean: pushing the energy envelope in tech industry buildings. LBNL-1005070E. Lawrence Berkeley National Laboratory, Berkeley, California.
11. Fisk W.J., W.R. Chan, and T. Hotchi. 2015. Prototype systems for measuring outdoor air intake rates in rooftop air handlers. LBNL-181030. Lawrence Berkeley National Laboratory, Berkeley, California.
12. Chan W.R. and B.C. Singer. 2014. Measurement-based evaluation of installed filtration system performance in single-family homes. LBNL-6607E. Lawrence Berkeley National Laboratory, Berkeley, California.
13. Chan W.R., F.R. Carrie, J. Novak, A. Litvak, F. Richieri, O. Solcher, W. Pan, and S. Emmerich. 2012. Building air leakage databases in energy conservation policies: analysis of selected initiatives in 4 European countries and the USA. Air Infiltration and Ventilation Centre, Energy Conservation in Buildings and Community Systems Programme, International Energy Agency.

14. Chan W.R., J. Joh, and M.H. Sherman. 2012. Analysis of Air Leakage Measurements from Residential Diagnostics Database. LBNL-5967E. Lawrence Berkeley National Laboratory, Berkeley, California.

15. Chan W.R., M. Sidheswaran, D. Sullivan, S. Cohn, and W.J. Fisk. 2012. Healthy Zero Energy Buildings (HZEB) Program–Interim Report on Cross-Sectional Study of Contaminant Levels, Source Strengths, and Ventilation Rates in Retail Stores. LBNL-5953E. Lawrence Berkeley National Laboratory, Berkeley, California.

16. Chan W.R. and F. Noris. 2011. Side-by-Side Comparison of Particle Count and Mass Concentration Measurements in a Residence. LBNL-5327E. Lawrence Berkeley National Laboratory, Berkeley, California.

17. Price P.N., A. Shehabi, and W.R. Chan. 2007. Indoor-outdoor air exchange rates of California apartments and commercial buildings. California Energy Commission, CEC-500-2006-11.

18. Chan W.R., P.N. Price, and A.J. Gadgil. 2004. Sheltering in buildings from large-scale outdoor releases. Air Infiltration and Ventilation Centre, Ventilation Information Paper No. 10.